Cryomodule 40 K Thermal Cycle SOP

APPROVALS

Signoff: _____ Date: _____

Ops Reviewer Signoff: _____ Date: _____

Temporary ? Yes / No

Procedure Title: **Cryocycle of a Cryomodule to >25 K to Cleanup Waveguide and Beamline Vacuums - SL11 & SL12**

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Brief Purpose

To improve the useable gradient in some cavities by cleaning up some of the gas load in the waveguide vacuum region. This will make the modules capable of supporting higher energy operation of the accelerator. Also, this procedure is used following helium processing to remove the helium from the beamline surfaces.

Anticipated Benefits

This process allows the adsorbed hydrogen, helium, and perhaps also some nitrogen to be pumped out. Some cavities are presently limited in gradient by the stability of the waveguide vacuum. We anticipate an increase in the usable voltage of the modules.

Beam Conditions Required

no beam - gate valves will be shut for the duration

Time Required

18 hours

Preferred Time

downtime, maintenance, or machine development.

Staff Required to Execute the Procedure (including contact info)

Joe Preble x7445, John Fischer x7408, Greg Marble x5116, Kurt Macha? x7407, Ganapati Myneni x7657, Chas. Reece X7645

Controlled Access Requirements

To change vacuum valve cabling and pump on WG vacuums as needed.

Hardware and/or Software Changes Required

Beamline valve controls

Install turbo on beamline between modules.

Setup Procedure

PRELIMINARY SETUP STEPS

1. **RF off.**
2. **Stage turbopumps for use on the waveguide vacuums if necessary.**
3. **Isolate the CMs - close beamline valves.**
   - **a.** Turn off ion pumps VIP2L11B, VIP2L12A, and VIP2L12B.
   - **b.** Confirm that this closed the gatevalves if the normal controls are in place.
   - **c.** Attach local controllers on valves on girder 2L12.(VBV2L11B, VBV2L12A)
   - **d.** Isolate the (pair of) CM(s) - disconnect valve control cables for the 4 gate valves from the valve controller chasis in the service building, noting both cable label and jack label. (Make elog entry noting this change.)(VBV2L11A, VBV2L11B, VBV2L112A, VBV2L12B)
   - **e.** Attach control cable for VAT valve to turbopump, **V3** in figure below, (use the control cable for V12A)
   - **f.** Attach control cable for V3 to manual controller in service building and confirm proper function. Leave the valve in the closed position.
4. **If cycling prior to helium processing, we would like to measure the gas load desorbed so:**
   - **a.** Close the Granville-Phillips fine control valve, **V6**.
   - **b.** Close the VAT valve, **V3** in figure below, to isolate the turbopump.
   - **c.** Confirm vacuum integrity of the gas manifold by observing the RGA response.
   - **d.** Open the gatevalves between the two cryomodules on girder 2L12 using the manual controllers.(VBV2L11B, VBV2L12A)
   - **e.** Open the pumpdrop isolation valve, **V5**, on VIP2L12B.
   - **f.** Record the baseline RGA spectrum. Print hardcopy and save a file.
   - **g.** Datalog Partial pressures vs. time to correlate with temperature as the cryomodules warm up.
5. **If removing helium from the beamline following helium processing:**
   - **a.** Keep the gatevalves between the two cryomodules open.
   - **b.** Note the initial pressure on the RGA and ensure that it is logging .

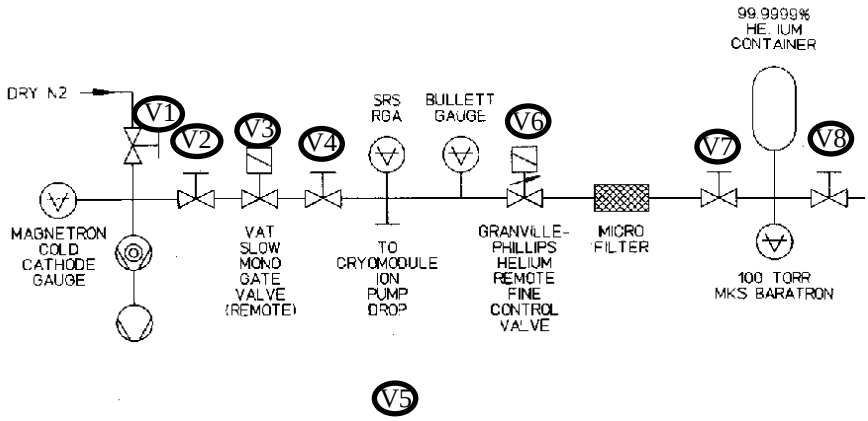
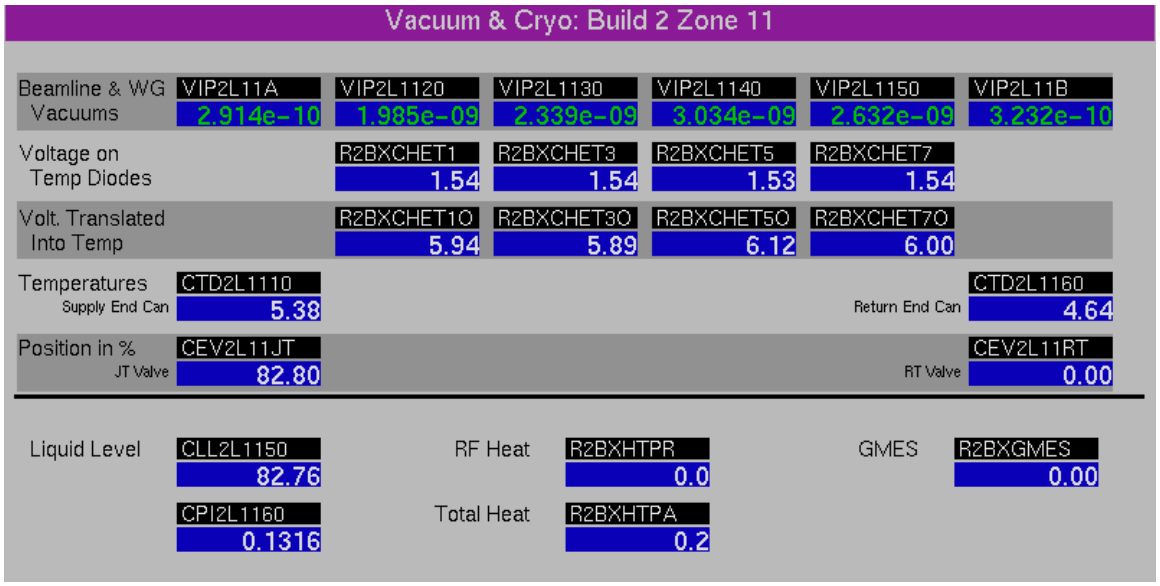


Figure 1.

6. **Start logging:**
   ```
   cd ~reece/logging
   ~brown/bin/kalog cryocyS1112.n 30 4 cryocyS1112.dat &
   ```
7. **Verify that logging is active. (log file `cryocyS1112.dat` appended every 30 seconds.)**
8. **Open `/usr/user3/reaves/dm/highgradm.adl` and select these zones. From this screen, open the Vacuum and Cryo screens for a convenient collection of signals for monitoring.**



Procedure

1. **Prior to boiling off LHe, change the low level alarm to -999 on the guard alarm setpoint screen.**

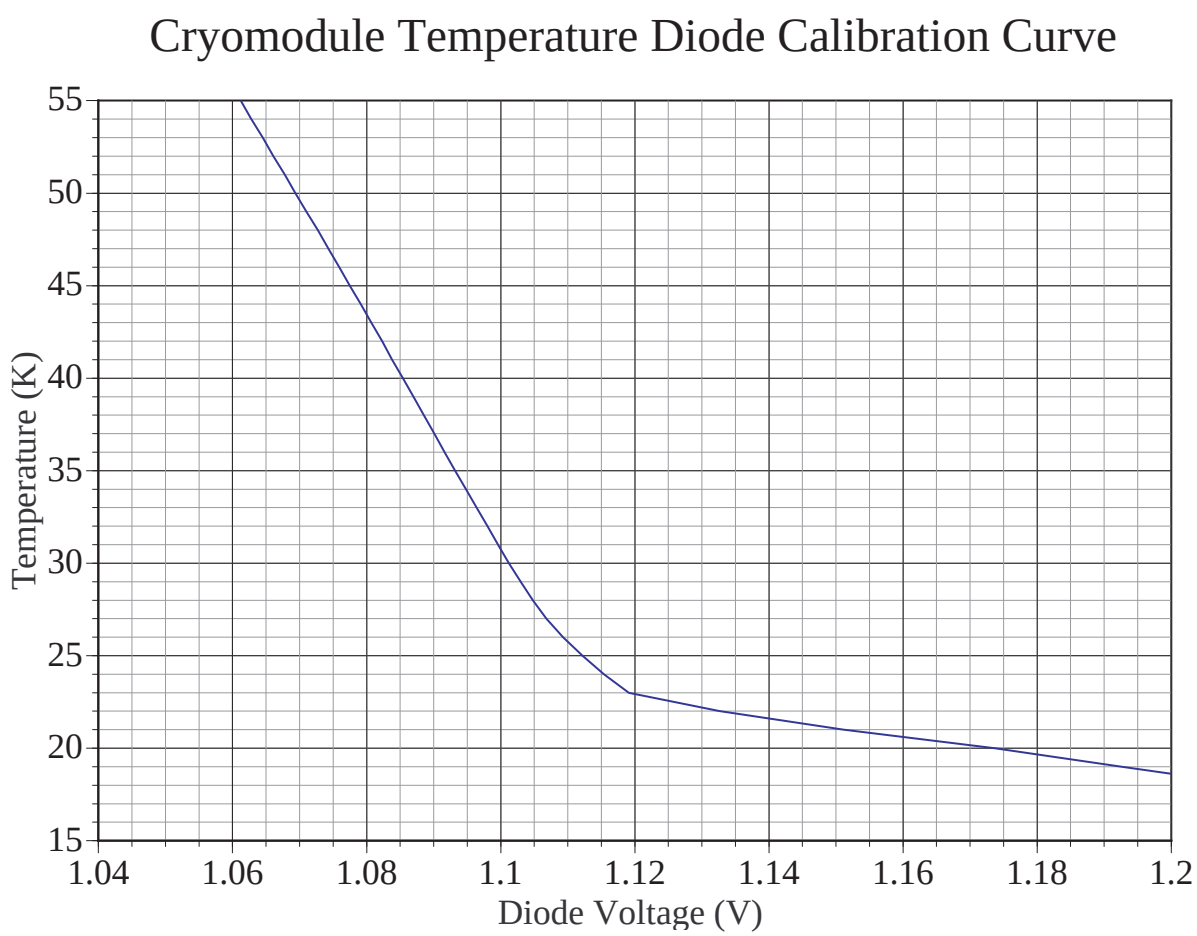
Note that all transitions of cryo-related parameters should be done slowly and one module at a time.

2. **Close the inlet JT valves one at a time (separated by 10 min.). Keep the RT valves open. Record all changes of valve position on a log sheet.**
   For details, see the procedure "JT and Heater Control for Thermal Cycling a Cryomodule" appended to the end of this general procedure.

3. **Note the following procedure for controlling the ramp target for rf heaters:**
   - **a.** Open the heater control page and a terminal window (e.g., xterm).
   - **b.** In the terminal window type "setenv AP_EPICS_HOST ctfsrv".
   - **c.** Each time you make a change in the requested heat, immediately run /usr/user2/cryo/bin/launch_make_delta in the terminal window.
   - **d.** Confirm (cancel) the operation by typing "y" ("n") and RETURN.
   - **e.** NOTE: When returning the module to normal operations, enter a requested heat that matches the other modules and run the script one last time.

4. **Boiloff will begin. Apply 150 watts to zone SL11 , this, together with ~15 watts static heat load, will empty the CM in about 8 hours.**
   - **a.** Ramp the applied heat to max power (150 Watts) over ~20 minutes. Note that the normal heat load is ~90 watts. This change is accomplished by setting the heater ramp target to 170 (ensuring that we are getting all the heat possible from the power supply).
   - **b.** Liquid level for these two modules are signals CLL2L1150 and CLL2L1250.
   - **c.** Make changes in heater settings in coordination with the CHL operator.
   - **d.** Contact for heater control during boiloff is Joe Preble x7445 or _____ then cryo-operator.

5. **About 10 minutes after SL11 heat is at ~>120 watts, start ramping up heat in SL12.**
6. **Monitor temperatures. - Setup striptools on the liquid levels.**
7. **When liquid level reaches ~5%, ramp down applied heat to 60 watts in each module in about 10 minutes.**
8. **Allow cavities and helium vessel temperature to rise while monitoring the temperatures indicated for the midplane diodes. (**Signal names:
   R2CXCHET1n, R2CXCHET3n, R2CXCHET5n, R2CXCHET7n
   and R2BXCHET1n, R2BXCHET3n, R2BXCHET5n, R2BXCHET7n
   These signals use improved look-up table conversion, available only in these zones.



9. **When <u>all</u> midplane diode temperatures indicate > 25 K (40 K is prefered) for more than 15 minutes or any one of these diode exceeds 45 K, turn <u>heater off</u> by putting rf heater in <u>KILL</u> mode. (If tunnel is open, or thermal state is problematic, consider supplemental monitoring by checking the "upper elbow" diodes on each pair to ensure that the cavities do not exceed 50 K. This can only be done in the tunnel. (This is not likely with the shield flow maintained and the heaters off.)**
10. **Confirm that the 11B and 12A beamline valves are both open.**
11. **Confirm and save partial pressure data logged on the RGA.**
12. **Open the beamline turbopump, V3 in Figure 1 above, using the valve controller in the service building.**
13. **If any waveguide ion pumps have tripped off, use supplemental turbo pumps to degass the waveguides. Then restart the ion pumps.**
14. **Dwell in this state above 25 K for at least 45 min.**
15. **Begin cooldown, slowly opening JT of <u>SL11</u>.**
16. **When Supply endcan diode temperature (CTD2L1110) begins to fall, restart the beamline ion pump VIP2L11B by <u>restarting the controller</u>. note: the pump may be**

touchy and require a few restarts. If problems, call : _____.

17. **Verify that ion pump is recovering.**

18. **Fill as appropriate for the cold compressors. (The sensitive part is the transient on opening the J-T valve and collecting the first 10%.)**

a. With the heater off (still in KILL mode), the fill rate may be slowly increased above 15% level then slowly reduced above 80%. (Note that in normal operation the typical JT-position is 39% open with 86 watts of heat (electric and RF).)

b. Common practice is to put control in auto with normal tune parameters after 30% level is reached. This is comfortable if the fill is to be unattended and time is not critical.

c. During refill, change the JT sample time to 15 seconds. (This reduces risk of overflow.)

19. **After the first module level shows 10%, begin opening the JT valve for the second module (SL12).**

20. **When Supply endcan diode temperature (CTD2L1210) begins to fall, restart beamline ion pumps VIP2L12A and VIP2L12B by their restarting controllers.**

21. **Valve out the turbopump on the beamline, by closing V3.**

22. **Fill both modules in parallel.**

23. **Log partial pressure behavior with the RGA.**

24. **Complete the fill gently, for each module:**

a. When liquid level reaches ~83% level, switch the EPICS heater control for that zone to kill mode with zero watts requested. *See Step #3 above for changing the heater ramp target* .

b. Immediately after ensuring the ramped target reads zero, make the requested heat match the other cryomodules and switch to auto mode. The auto-heater control should take over. Ideally, the level should reach 90.5% with no overshoot soon after the heat ramps up to setpoint.When LHe level has peaked and heater is near its setpoint, return the JT sample time to 120 seconds.

c. Restore the low liquid level guard alarm.

25. **Verify acceptable beamline vacuum reading.**

26. **Reestablish all vacuum valve controls and open the beamline valves.**

a. Reconnect all normal valve control cables and make elog to this effect.

b. Open all beamline gatevalves and confirm proper function.

27. **When power permit is available, establish running at nominal gradients for ops, monitoring for vacuum problems.**

28. **After establishing stability at nominal operating levels, increase gradients to levels where arcing or some other limit is expected.**

29. **As time permits, measure arc rate to distinguish if conditioning has occurred.**

JT and Heater Control for thermal cycling a cryomodule

1.0 Purpose

This procedure describes how to operate the cryomodule's JT valve and heaters for thermal cycling required in support of helium processing or waveguide processing.

2.0 Preparation

1. Initial Conditions: The cryomodule is in normal operation state.
   A. JT valve is controlling the LHe level.
   B. The RT valve is 100% open.
   C. No RF power.
   D. The cryomodule heaters are in auto.
   E. The shield valve maintains shield outlet temperature.
2. Recording Values
   A. Record the JT minimum and maximum position along with sample time.
3. Setup StripTool for:
   A. The cavity midplane diodes signals for he desired cryomodule found on the RF debug screen.
   B. Cryomodule inlet temperature. (CTDXLXX10)
   C. Helium Liquid Level. (CLLXLXX50)
4. Ensure the CHL or cryo-coordinator was notified prior of any cryo cycling.

3.0 Procedure

Boiling off the Liquid Helium

Closing the JT valve:

1. Set the sample rate on the JT PID loop, to 1 second.
2. Set the JT valve Min. set point and then the Max. set point to -20%

(The JT valve should close in 2-5 minutes.)

Raising the heater power

1. In the epics heater control screen, enter 170 Watts for the heater power value. (See page 4, step 4.)
2. Run the script file to lock in the desired power level.(See page 4, step 3.)

3. Allow the software to ramp up the heat to the desired power level.

Monitoring the boiloff.

1. The StripTool setup earlier will show rate of liquid Helium boiling off. From 90% full of liquid, it should take about 7 hours to reach 5% LL.

Caution

Under no circumstances should more than 60 Watts of heat be going into the heaters below 2% liquid level.

Turning down the heaters after reaching 5% liquid level.

1. In the epics heater control screen, enter 60 Watts for the heater power value.
2. Run the script file to lock in the desired power level.
3. Allow the software to ramp up the heat to the desired power level.

Monitoring the warm-up

1. Monitoring the StripTool setup you can see the Liquid Level drop to 0%. (.5-1 Hour)
2. The cavity midplane temperatures will slowly rise. After the midplane temperatures reach ~35 K, turn off the heat.

Turning off the heat after reaching >25 K for more than 15 minutes or when any one cavity midplane diode exceeds 45 K.

1. In the epics heater control screen, enter 0 Watts for the heater power value.
2. Run the script file to lock in the desired power level.
3. Putting heater in KILL mode will provide a hard OFF state for the heater. After the cavity midplane temperatures read between 25K and 40K for at least 30 minutes, the cooldown can begin.

Sneaking open the JT valve.

1. Check that the RT valve is open.
2. Open the JT valve to +5% by changing the Max. then the Min. settings of the valves.
3. In about 5 minute intervals open the JT valve in 5% increments.

   A. Monitor the CC suction (CPICCSUC) while opening the JT valve. It should not increase or decrease more than .002 atm.. If it does close the JT 5% and open slower.

Monitor the inlet temperature of the cryomodule. (CTDXLXX10)

1. The inlet temp. (seen on the StripTool) will rise as much as 200K before dropping to 4-5K. This is due to the heat load of the transfer line and no gas flow.

After reaching 35% open on the JT and the inlet temperature is below 5K.

1. The JT can be changed in 10% increments until you reach the original value before warm-up.
2. Set the sample rate on the JT PID loop, back to it's original setting.
3. The Min. JT setting can now be changed back to it's original setting.
4. Set the Liquid level set point to 85%.

After the Liquid level in the cryomodule is more than 20%.

1. In the epics heater control screen, enter 70 Watts for the heater power value.

After the Liquid level in the cryomodule is at 85%.

1. Raise the Liquid level set point to 90.5%.
2. Ensure all the original values are restored.

Results